ES78-MSFC-2241

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Final Report

STS PAYLOAD DATA COLLECTION AND ACCOMMODATIONS ANALYSIS STUDY

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Volume III - Accommodations Analysis

August 1978

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ES78-MSFC-2241

STS PAYLOAD DATA COLLECTION AND ACCOMMODATIONS ANALYSIS STUDY

FINAL REPORT

VOLUME III

ACCOMMODATIONS ANALYSIS

AUGUST 1978

PREPARED FOR

INTEGRATED PAYLOAD AND MISSION PLANNING OFFICE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER

CONTRACT NO. NAS8-32711

PREPARED BY

SPACE SYSTEMS DEPARTMENT
ENGINEERING SERVICES DIVISION
TELEDYNE BROWN ENGINEERING
HUNTSVILLE, ALABAMA

FOREWORD

This report summarizes the results of the Space Transportation System Payload Data Collection and Accommodations study (Contract NAS8-32711) performed by Teledyne Brown Engineering Company for the MSFC Integrated Payload and Mission Planning Office from August 24, 1977 to August 25, 1978. This study consisted of two basic tasks:

Task 1 - Payload Data Collection

Task 2 - Spacelab Payload Accommodations Analysis.

This report consists of the following:

Volume I - Executive Summary

Volume II - Payload Data Collection

Volume III - Accommodations Analysis.

The results of this study can be found in greater detail in various other reports published during the term of the study. These reports are:

Task 1 - ES78-MSFC-2251, OSTA Payload Planning Data, Volumes I and II, August 1978

Task 2 - ES77-NASA-02168, Accommodations Versus Space Payload Requirements, December 1977

ES77-NASA-2168, Assessment of Launch Site Accommodations Versus Spacelab Payload Requirements, December 1977

Launch Site Processing Requirements, April 1978

Presentation to NASA JURG Spacelab Payload Accommodations Assessment from User's Viewpoint, May 1978

ES78-MSFC-2213, Spacelab Payload Planners Handbook, May 1978

Spacelab Accommodations Assessment for Earth Observations, Combined Astronomy, and Dedicated Life Sciences, August 1978

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ABSTRACT

This volume presents the results of accommodations analyses performed under this contract during August 1978. The analyses include a comparison of payload requirements to launch site accommodations and flight accommodations for a number of Spacelab payloads. They also include experiment computer operating system accommodations, a summary of accommodations in terms of resources available for payload discretionary use and recommendations for Spacelab/STS accommodation improvements.

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1.0 INTRODUCTION

The purpose of Task II, Contract NAS8-32711, Payload Accommodation Analysis has been to determine the ground and flight accommodation requirements for STS/Spacelab payloads and missions, define flight and ground accommodations from available facility descriptions and to assess the adequacy of accommodations against payload requirements. Figure 1 illustrates the operation of our accommodations analysis effort using documented user requirements and facility descriptions to develop integrated payload requirements and accommodations descriptions which are used in the performance of accommodation assessments. Note that material from the user requirements, facility descriptions and integrated mission requirements were used in the generation and maintenance of the payload accommodation reference file.

Accommodation definition outputs were in the form of inputs to the NASA JURG presentation, Spacelab Payload Accommodations Assessment from the User's Viewpoint, and a Spacelab Payload Planners Handbook which defines and summarizes Spacelab accommodations in terms of resources available for payload (experiment) discretionary use. Integrated requirements for several missions were used in and published as part of accommodation assessments. Other accommodation assessments include consideration of experiment computer accommodations and an analysis of needed Spacelab payload accommodation improvements.

Analysis of ground operations included the definition of launch site processing requirements for selected payloads and the assessment of the accommodations at KSC (Figure 2) A primary objective of this effort was to provide KSC with a constructive review of the KSC accommodations handbook which was then undergoing revision. The analysis was conducted from the user's viewpoint and included processing requirements except test and checkout for which accommodation definitions were not then available. TBE was directed to prepare a document defining the launch site processing for generic Spacelab payloads as part of TBE's participation in the resolution of KSC test and checkout accommodations definition.

TBE participated in the OSTA cost study to the extent that integrated payload analysis were performed to determine the number and types of interfaces requiring integration and verification at Level IV.

FIGURE 1. PAYLOAD ACCOMMODATIONS ANALYSIS

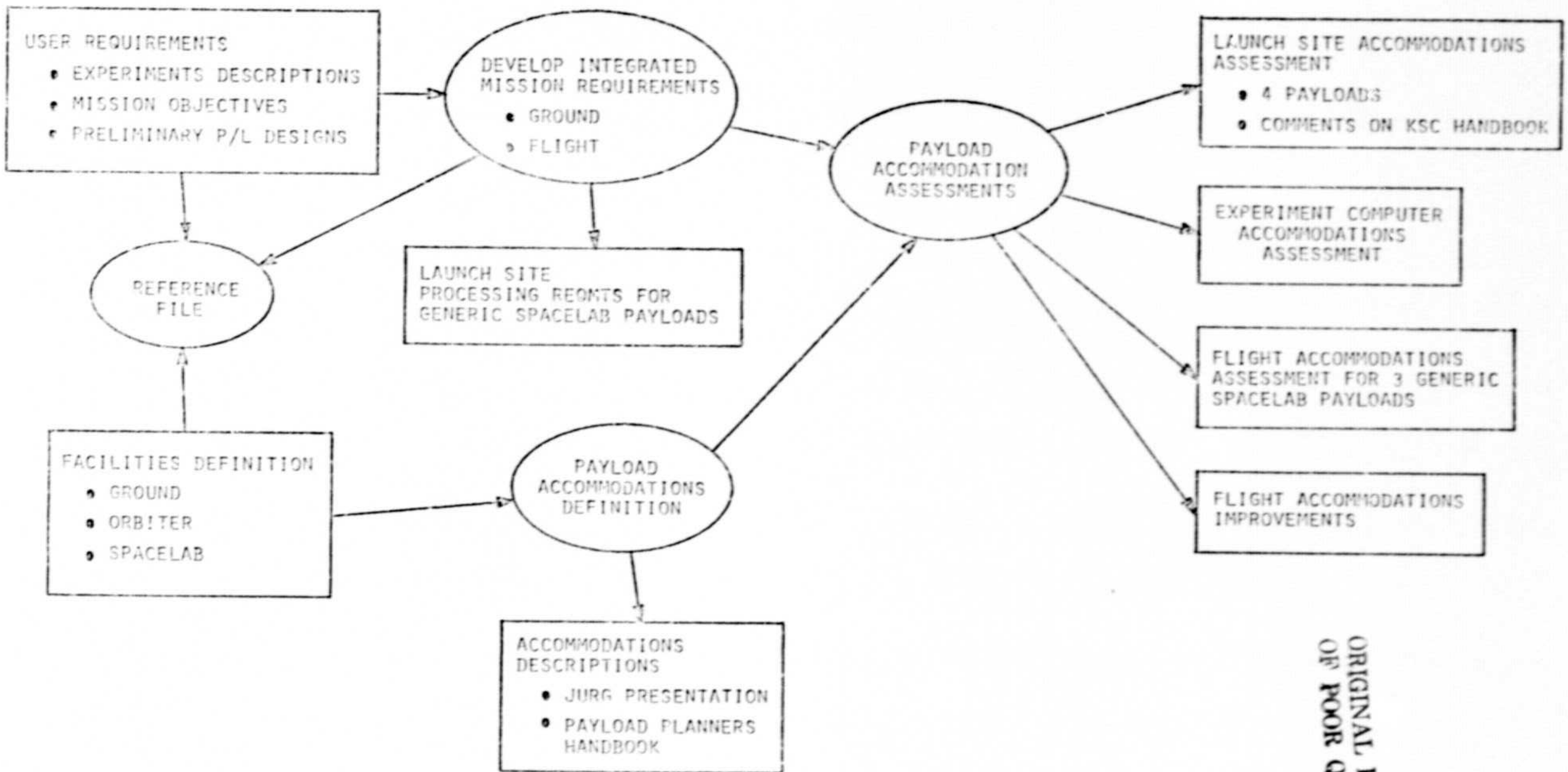

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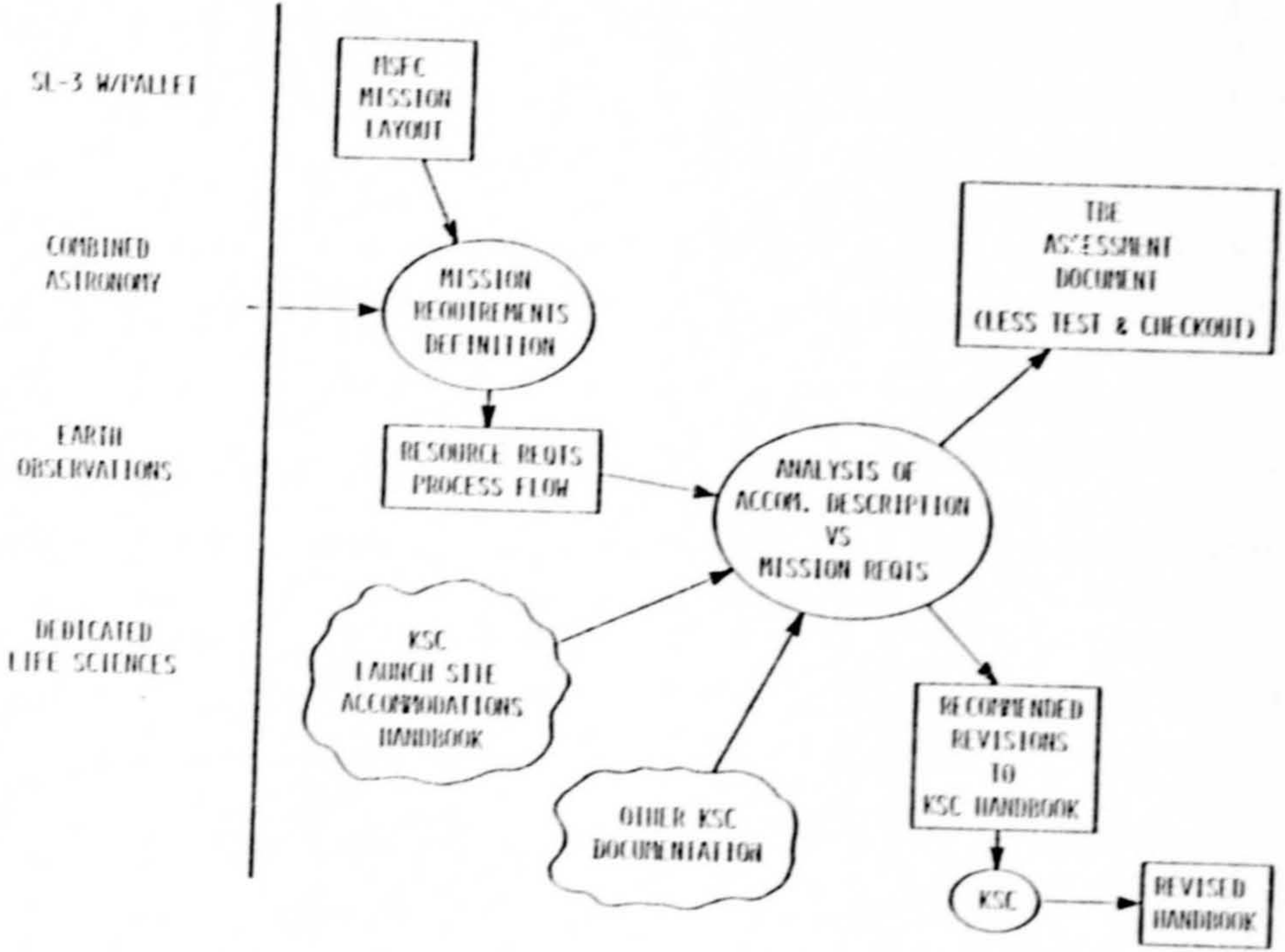
FIGURE 2. ASSESSMENT OF LAUNCH SITE ACCOMMODATIONS



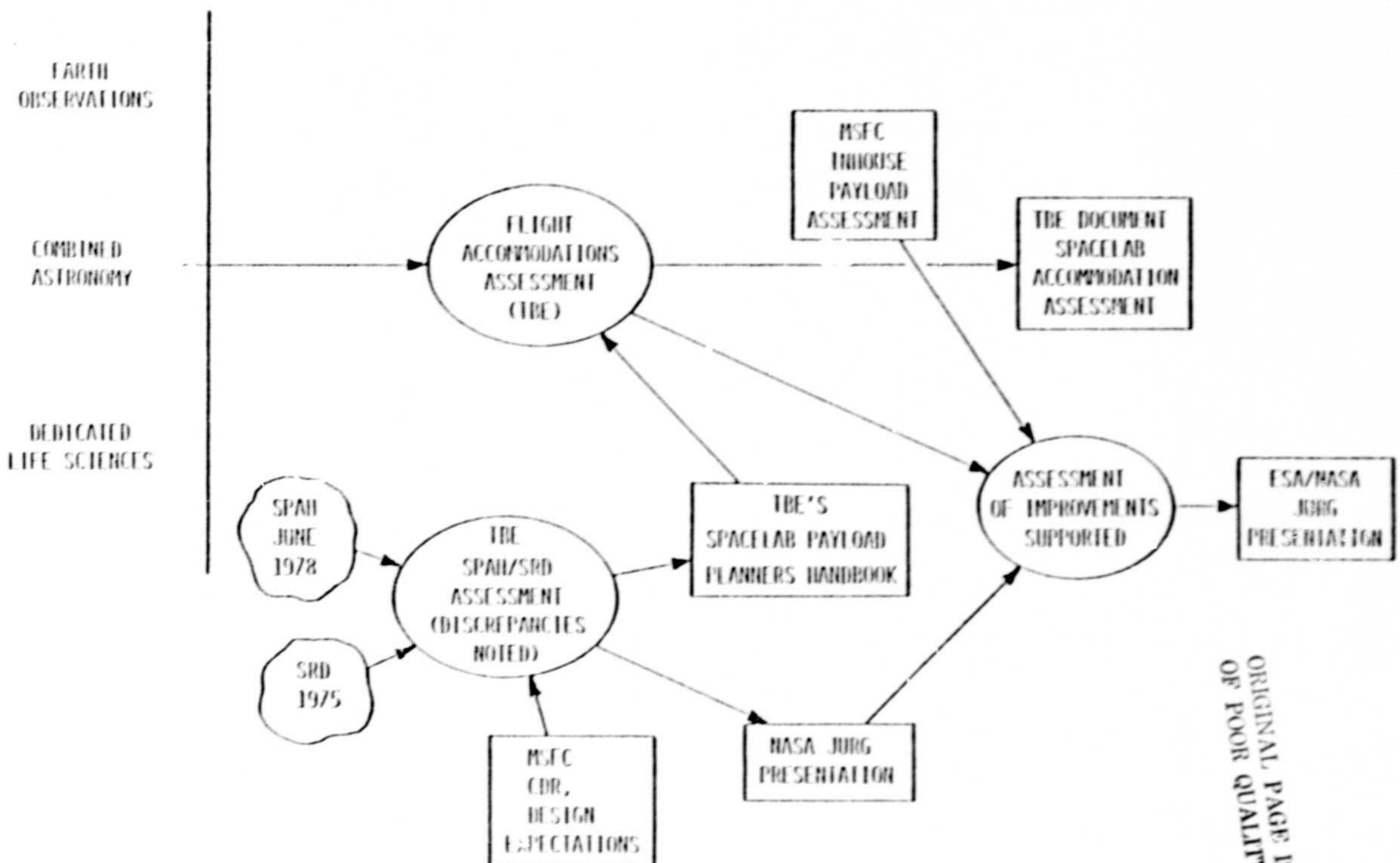
Flight accommodation studies were conducted to provide a basis for evaluating Spacelab payload accommodations. TBE was directed to determine the Spacelab payload accommodations available for payload discretionary use, provide a clear statement of Spacelab/STS constraints on payload operations, compare generic payload requirements with available accommodations, and to define needed improvements in Spacelab payload accommodations (Figure 3).

TBE contributed to the NASA JURG assessment of payload accommodations by providing a definition of accommodations for payload discretionary use, comparing these to initial requirements placed on Spacelab and including an evaluation of CDR/design expectation effects on accommodations. Based on this data, the Spacelab Payload Planners Handbook was published.

Integrated payload requirements were detemined from available data on these generic payloads: Earth Observations, Combined Astronomy and Dedicated Life Sciences. These requirements were used to assess the Spacelab payload accommodations and to evalute needed improvements.

A summary of the Task II studies is contained in Section 2 thru 5. Section 6 contains pertinent references including documents prepared under Task II of this contract.

FIGURE 3. FLIGHT ACCOMMODATION STUDIES



2.0 GROUND OPERATIONS ACCOMMODATIONS

2.1 LAUNCH SITE ACCOMODATIONS VERSUS SPACELAB PAYLOAD REQUIREMENTS (ES77-NASA-2168)

2.1.1 Summary

The overall purpose of this study was to compare the KSC launch site accommodations with Spacelab payload requirements. The KSC accommodations were defined, for the purpose of this study, by the KSC Launch Site Accommodations Handbook for STS Payloads. The study had three goals:

- Assess KSC accommodations versus requirements of four selected Spacelab Payloads
- Provide a critical review of the KSC accommodations handbook
- Define the provisions for payload checkout at KSC.

In order to meet the goals of this study, several tasks were undertaken. First, criteria for evaluation of the experiment accommodations described in the handbook were developed. These criteria consist of basic questions a payload planner or instrument developer would ask about ground operations. A detailed description of the ground process flow was also defined to show all the operational functions the payload would be subjected to at KSC. The questions and flow functions were combined in a matrix for rapid identification of accommodations versus process flow functions.

The second task was to develop the ground processing requirements for four Spacelab missions: Spacelab III(Strawman), Earth Observations, Dedicated Life Sciences and Combined Astronomy payloads. From the basic payload definition supplied, instrument requirements were collected into payload requirements. The payload requirements were delineated using the same matrix developed for accommodation assessment.

By comparing the payload requirements with the stated KSC accommodations, a number of anomalies were identified. In attempting to resolve the anomalies both KSC and experiment cognizant people were contacted. In some cases, the handbook could be clarified to show accommodation for a requirement. In other cases, the lack of accommodation was flagged to

the experimenter. This resulted in clarification or elimination of several experiment requirements which were not critical, but which would have created problems in making the accommodations available.

Two significant results of this study were flagging of unaccommodated requirements to experimenters and the development of constructive suggestions which have been given to KSC for revision of the handbook.

It was not possible, in the time frame of this study, to define the payload checkout provisions at KSC. This was because the basic requirements for checkout were not agreed upon by KSC and other NASA centers. Toward this end TBE was directed to prepare Summary Report ES-MSFC-2194, Launch Site Processing Requirements for Spacelab Payloads (Reference 3). Mission descriptions and study findings are summarized in the following sections.

2.1.2 Spacelab III (Strawman)

2.1.2.1 Mission Definition

The mission presented in this section is one of several "strawmen" versions for Spacelab III (SL-3). The payload is a long module with a single three meter pallet as shown in Figure 4.

There are three OSTA instruments on the pallet and seven OSTA instruments in the module. The module also contains two non-OSTA instruments, and a single spare rack. The instruments and their locations are listed in Table 1. It should be noted that the Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) experiment was added and the Materials Experiments Assembly deleted per NASA direction. In the drawing of Figure 4, the ATMOS is shown in what was a spare rack and is not necessarily the true location. Also not shown is an N_2 sphere located on the pallet which supports the ATMOS sensor when it is in the airlock.

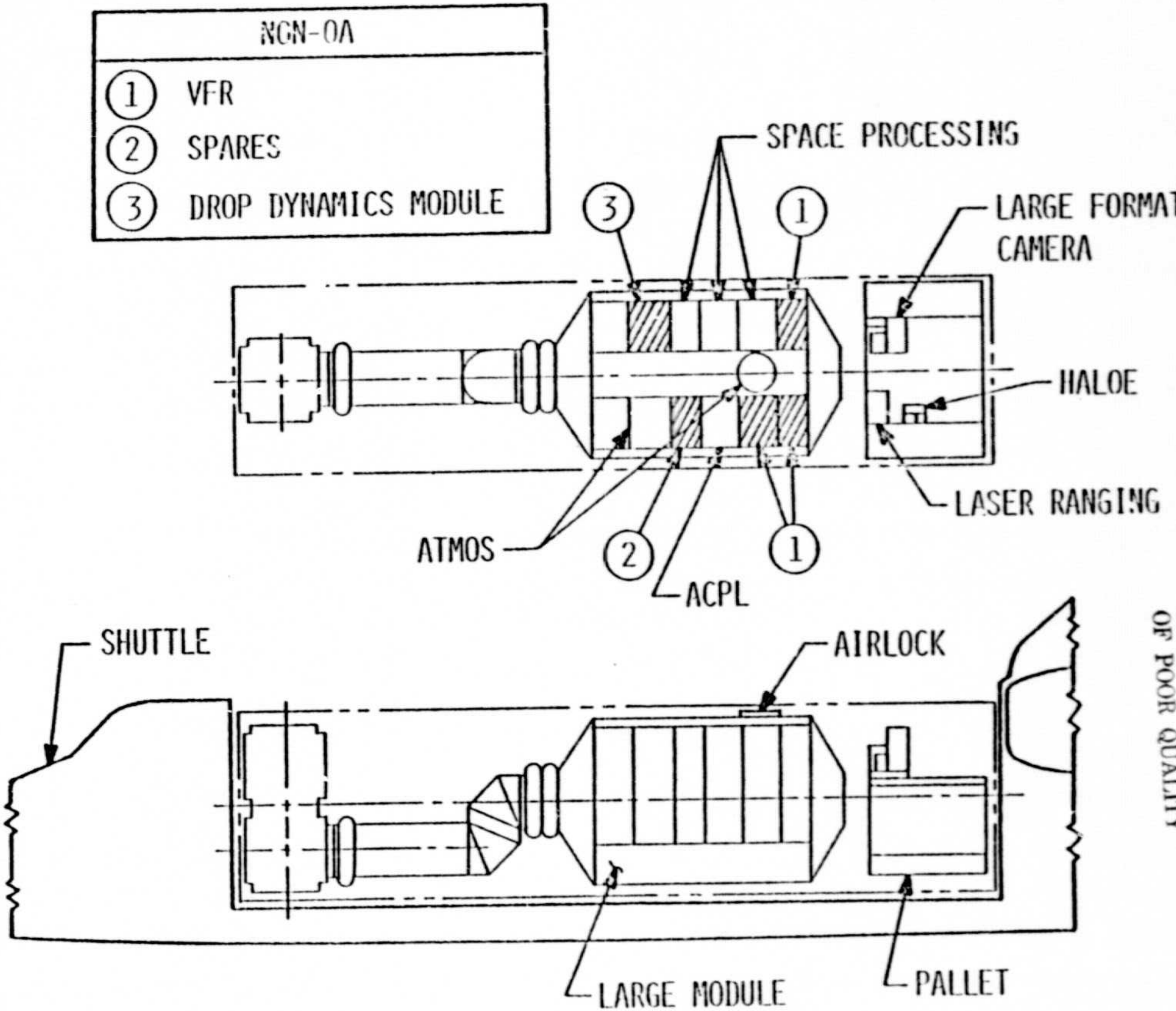
2.1.2.2 Summary of Spacelab III (Strawman) Anomalies

It should be noted that data were not available for three experiments due to their status of "out of bid". These three are (1) Polymer Reaction, (2) Unique Bio. System, and (3) Unique Two-Zone Low Temperature Furnace.

TABLE 1. SPACELAB III STRAWMAN INSTRUMENTS

INSTRUMENTS	LOCATION
LARGE FORMAT CAMERA (LFC)	PALLET
HALOGEN OCCULTATION EXPERIMENT (HALOE)	PALLET
LASER RANGING	PALLET
MULTIFLUIDS PROCESSING FACILITY	MODULE
FLOAT ZONE REFINING SYSTEM	MODULE
POLYMER REACTION	MODULE
UNIQUE BIOLOGICAL SYSTEM	MODULE
UNIQUE 2-ZONE LOW TEMP. FURNACE	MODULE
ATMOSPHERIC CLOUD PHYSICA LAB. (ACPL)	MODULE
VESTIBULAR FUNCTION RESEARCH (VFR)	MODULE
DROP DYNAMICS MODULE (DDM)	MODULE
ATMOSPHERIC TRACE MOLECULES OBSERVED BY SPECTROSCOPY (ATMOS)	MODULE

FIGURE 4. SPACELAB III STRAWMAN PAYLOAD CONFIGURATION



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Data were used from a three-zone furnace experiment in place of (3). The extraordinary requirements of this payload mainly involve time of access.

The Vestibular Function Research (VFR) experiment requires intermittent testing for five days prior to launch. Since the flight equipment will be integrated into the Spacelab module during this time, access to it will not be available. The data source states that this problem has not been addressed at this time but that the back-up set of equipment will probably be utilized for this testing at KSC.

The specimens for the VFR experiment (four instrumented, constrained frogs) will have to be a "carry on" item just prior to launch due to the requirements that they remain belly down. Also specimen testing or data taking is performed for 30 minutes just before launch, through injection into orbit, during descent and upon touchdown (10 minutes before and 30 minutes after touchdown).

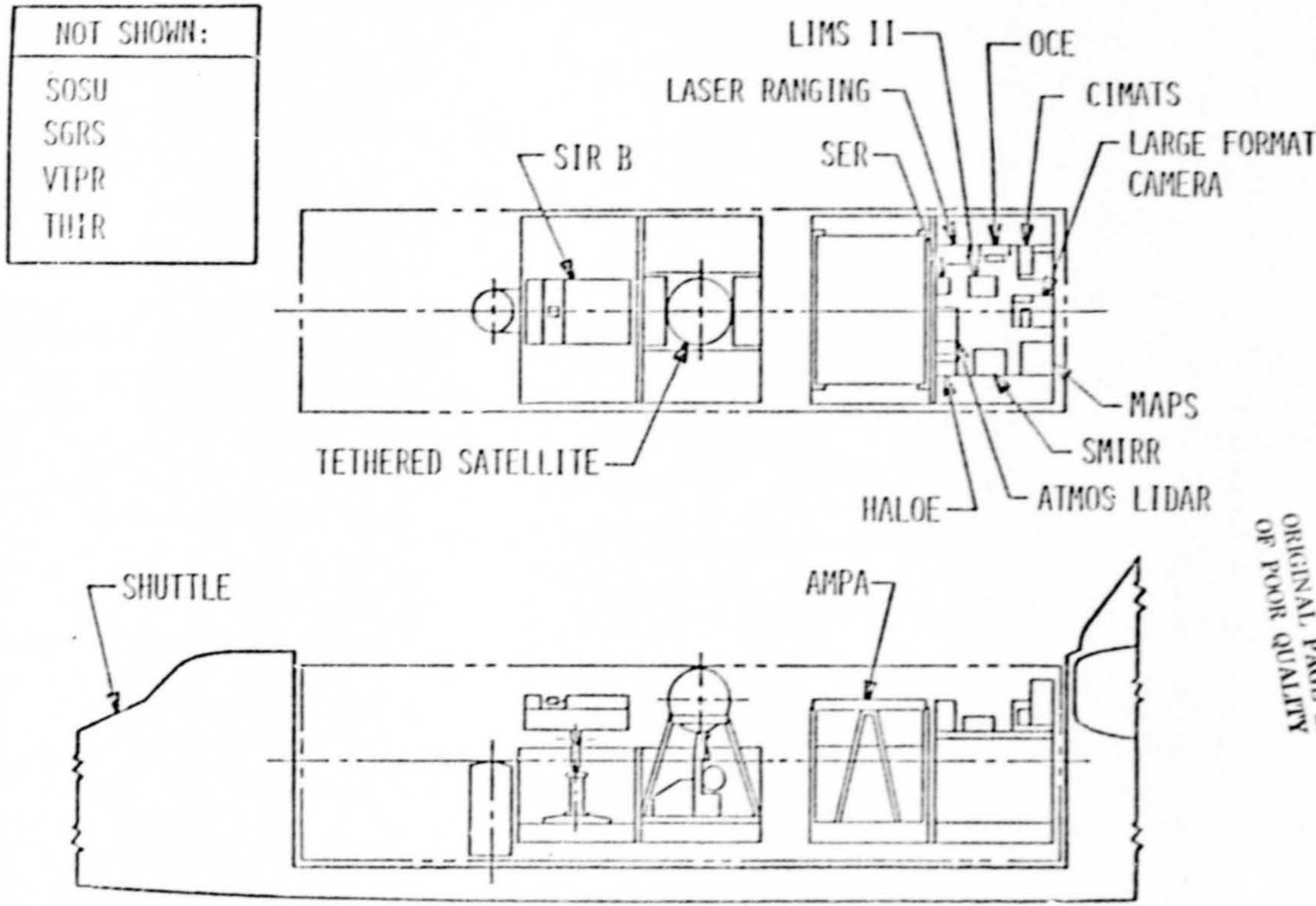
The ATMOS sensor will be installed in the module airlock for experimentation during orbital operation. The instrument must be extended from the airlock and boresighted during ground operations. The airlock experiment table deployment mechanism is not designed for 1-g operation. Since the table will require deployment into the module for equipment mounting prior to boresighting, a user supplied 1-g table support kit (GSE) will be utilized. This function should be performed prior to mating the module aft end cone for ease of access with GSE.

2.1.3 Earth Observation Mission

2.1.3.1 Mission Definition

The 16 earth pointing OSTA instruments of this Earth Observations mission are mounted on five standard 3-m pallets four of which are shown in Figure 5, Earth Observation Mission Payload Configuration. Originally the Passive Microwave instrument which attached directly to the Orbiter at the forward end of the payload bay was included in the payload. The Passive Microwave was later deleted and the Standard Ozone Sounding Unit (SOSU), Shuttle Geodynamics Ranging System (SGRS), Temperature Humidity Infrared Radiometer (THIR) and Vertical Temperature Profile Radiometer (VTPR) instruments were added. These were assumed to be pallet mounted in the forward end of the payload bay. These experiments controlled from the aft flight deck, are semi-automatic

FIGURE 5. EARTH OBSERVATION PAYLOAD CONFIGURATION



in their operation, i.e. little more than on-off commands are required. SIR-B, AMPA and TETHER are deployed beyond the payload bay envelope during operation. The list of experiments and acronyms is given in Table 2, Earth Observation Mission Instruments.

The paucity of information on some of the experiments demanded the synthesis of integrated payload requirements. These experiments are indicated in Table 2 with an asterisk. All experiments needed some synthesis of requirements for ground operations since even the most detailed experiment definitions did not sufficiently detail the ground operations.

2.1.3.2 Summary of Earth Observation Anomalies

Since SIR-B, AMPA and TETHER are deployed beyond the payload bay envelope, they must be provided with release devices to allow emergency jettisoning. These devices were assumed to be pyrotechnic in the final design.

Both CIMATS and LIMS use LN_2. This use generated the requirements for cryogenic servicing prior to experiment calibration in the O&C building and again as soon as accessible after return. LN_2 servicing was not indicated as being normally available in the O&C. It was assumed that post-flight servicing of the LFC is required to vent the high perssure GN_2 tank.

2.1.4 Dedicated Life Sciences

2.1.4.1 Mission Definition

The Dedicated Life Sciences mission consists of a long module containing instruments to carryout 24 experiments listed in Table 3 in the life sciences discipline. As shown in Figure 6, racks 1 and 2 contain Spacelab equipment and all remaining racks are dedicated to life sciences. Additional instruments are mounted in the center aisle of the module, and in the Orbiter. The matrices of Tables 4, 5 and 6 list the location, name and the experiments on which the instruments are used.

The specimens utilized for experimentation in this payload consist of approximately 500 fruit flies, 98 rats, 39 mice, 6 frogs, 3 monkeys, and the crew members. The data source for this analysis is the Ground Processing

TABLE 2. EARTH OBSERVATION MISSION INSTRUMENTS

INSTRUMENT	ACRONYM
Shuttle Imaging Radar-B	SIR-B
Tethered Satellite	TETHER
Adaptive Multibeam Phased Array	AMPA
Measurement of Air Pollution from Sattellites	MAPS
Correlation Interferometric Measurements of Atmospheric Trace Species*	CIMATS
Halogen Occulation Experiment	HALOE
Solar Extinction Radiometer	SER
Advance Limb IR Monitoring of Stratosphere* (use information from lower atmospheric composition and temperature experiment)	LIMS II
Ocean Color Experiment	OCE
Shuttle Multispectral IR Radiometer Experiment	SMIRR
Large Format Camera	LFC
Lidar Measurement of Cirrus Clouds and Aerosols	ATMOS LIDAR
Shuttle Geodynamics Ranging System*	SGRS
Standard Ozone Sounding Unit*	SOSU
Temperature Humidity Infrared Radiometer	THIR
Vertical Temperature Profile Radiometer*	VTPR

*Experiment Requirements Synthesized

FIGURE 6. DEDICATED LIFE SCIENCES PAYLOAD CONFIGURATION

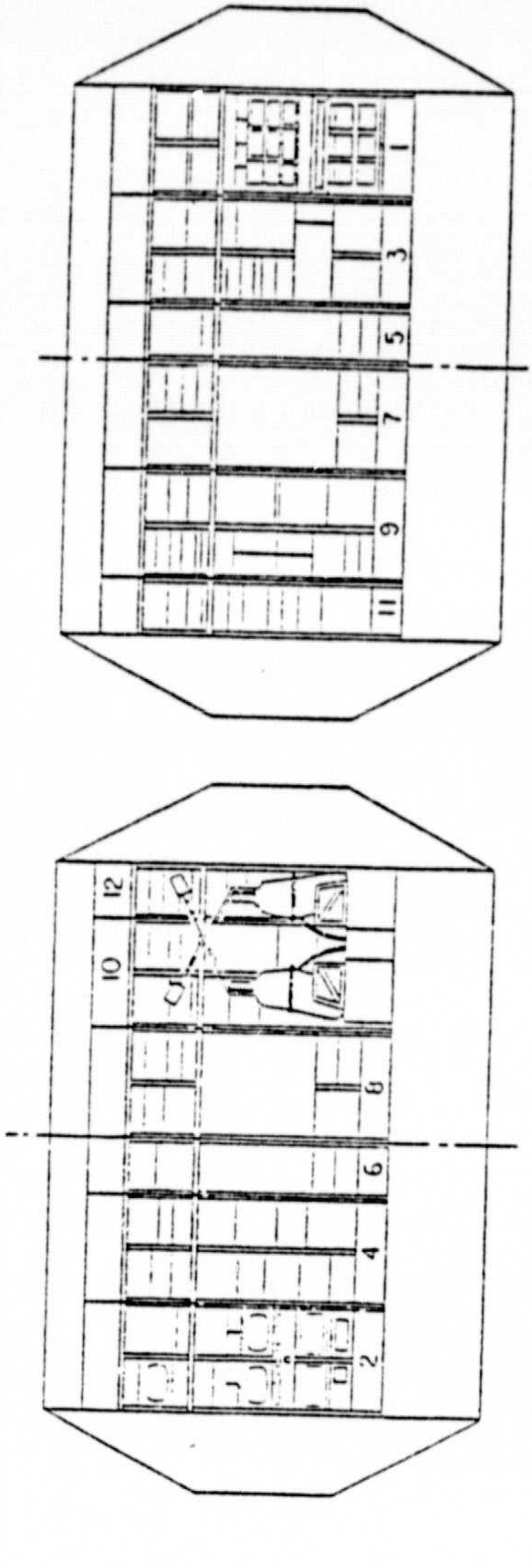


TABLE 3. LIST OF DEDICATED LIFE SCIENCES EXPERIMENTS

EXP.NO.	TITLE
X3	RAT COLLAGEN TURNOVER
X5	BIOFEEDBACK
X8	INSULIN RESISTANCE
X10	RAT PLASMA SOMATOMEDIN CONCENTRATION
X11	RAT URINARY EXCRETION OF 3-METHYL HISTIDINE
X12	RAT PROTEOLYTIC CONCENTRATION IN MUSCLE
X13	IN VIVO MUSCLE PROTEIN DEGRADATION
X15	MONKEY STATIC-OTOLITH ACTIVITY CHANGE
X21	MICE VESTIBULO-CEREBELLUM-VOMINTING CENTER & HYPOTHALAMIC-PITUITARY-ENDOCRINE AXIS
X23	RAT BRAIN AND RENAL RENIN-ANGIOTENSIN FUNCTION
X27	RAT LYMPHOID TISSUE HISTOPATHOLOGICAL CHANGES
X39	MONKEY RESORPTION RATE CHANGES
X42	DROSOPHILA DEVELOPMENT AND AGING
X49	HUMAN CARDIOVASCULAR ALTERATION
X51	MOTION SICKNESS FACTORS
X58	HUMAN PULMONARY FUNCTION
X59	RAT METABOLISM AND HEAT BALANCE
X60	RATS PYROGENIC FEVER--SALICYLATE/INTERACTION
X66	OTOLITH RESPONSE ADAPTATION AS A FUNCTION OF CNS OUTPUT
X68	ERYTHROKINETICS IN MAN
X74	CELLULAR IMMUNE RESPONSE IN MAN
X75	BASAL AND LIGHT ACTIVITY METABOLISM
X76	MONKEY CARDIOVASCULAR DYNAMICS, HEMOLYSIS, METABOLIC CARDIOVASCULAR ADAPTATION
X77	URINE ELECTROLYTE DETERMINATION

TABLE 4. MATRIX, LIFE SCIENCES EQUIPMENT-PORT RACK INSTALLATION

RACK		NAME	END ITEM	OTR	CORE	EXPERIMENT NO.																								OPERATING POWER (W)	
S/L	L/S					3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77	AC	DC
11	1	STORAGE - PERFUSION PUMP	21-1											X																	
		DROSOPHILA STORAGE	42-2															X												-	-
		OSCILLOSCOPE (POD) SELECTOR	76-7																									X		25	-
		DEMODULATOR PATCH PANEL	76-6																									X		-	-
		TELEMETRY TUNE/RECEIVER	76-4																									X		20	-
		DEMODULATOR	76-5																									X		25	-
		UPPER POD A FLOW CONTROL	76-30																									X		50	-
		TELEMETRY TUNE/RECEIVER	76-16																									X		20	-
		DEMODULATOR	76-17																									X		25	-
		UPPER POD B FLOW CONTROL	76-11																									X		50	-
		(SPACELAB - EPSP)	-																											-	-
9	2	ISOLATION AMPLIFIER	13-6									X	X																	50	-
		SIGNAL CONDITIONER	15-3										X																	50	-
		STRAIN GAUGE PWR SUPPLY	15-2										X																	-	-
		SCOPE SELECTOR	15-4										X																	-	-
		AC POWER FILTER	15-6										X																	-	-
		OSCILLOSCOPE	15-5										X																	200	-
		IR ANALYZER/OUTPUT MONITOR	13-2									X																			25
		IR ANALYZER/GAS FLOW CALIB.	13-3									X																			
		RESPIRATORY CAGES	13-1									X																		540	-
		VIBRATION REED ELECTROMETER	13-4									X																			
		VIBRATION REED ELECTROMETER	13-5									X																			
	3	STORAGE	-																											-	-
		DIGITAL TAPE RECORDER	75-6																									X			200	-
		DROSOPHILA CAMERA (STOW)	42-1															X												-	25
		REFRIGERATOR RAT FOOD	3-4			X			X	X	X	X		X	X	X						X	X		X					150	-
		SLIDE TABLE	-																											-	
		FREEZER	3-5		X	X		X	X	X	X	X		X	X		X	X							X	X		X		250	
		(SPACELAB - EPSP & RAU)	-																											-	29
7	4	BSHF WATER SUPPLY	15-11										X			X														50	-
		STORAGE - MONKEY PODS	76-26																									X		-	-
	4/5	PRIMATE HOLDING UNIT	15-7	14/16									X			X														480	20
	5	BENCH	-																											-	
		A-C INVERTER - 60 HZ	15-12			X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X		-	
		PRIMATE H.F. CTRLS/DISPL.	15-8										X				X													(F/O	(15-7)
		SPACELAB - ICRS - - EPSP	-																											-	-
5	6	RODENT WATER SUPPLY	10-3						X			X				X	X						X		X					50	-
		RODENT H.F. CTRLS/DISPLAY	10-2						X			X				X							X		X					50	-
		RODENT HOLDING FACILITY	10-1	14/16					15			6				20							6		14					-	-
		SPACELAB - EPSP)	-																												
	7	TV MONITOR	49-8																											75	-
		OSCILLOGRAPHIC RECORDER	49-2																											350	-
		TIME CODE GENERATOR	66-1																					X						-	26
		AUDIO MONITOR	66-2																					X						-	60
		MICRODRIVE	66-3																					X						-	4
		POWER MODULE AND STRIP	66-4																					X						-	10
		OSCILLOSCOPE	66-5																					X						-	29
		REFRIGERATED CENTRIF.	8-3.1		X			X	X									X							X	X				350	-
		REFRIGERATOR	8-4		X	X		X	X			X	X	X	X	X		X						X	X	X		X		250	-
	8	CARDIOTACH, FLOW MTR, PR. VIBR.	49-3																X		X									71	-
		ECHOCARDIOGRAM AND TV CAMERA	49-1																X											65	-
		ISOLATION AMPLIFIER	66-10																X					X						50	-
		ROTATING BASE CONTROL CONSOLE	49-5																X	X				X						-	300
		(SPACELAB - EPSP AND RAU)	-																											-	29

TABLE 5. MATRIX, LIFE SCIENCES EQUIPMENT-STARBOARD RACK INSTALLATION

RACK S/L	RACK L/S	NAME	END ITEM	OTR	CORE	3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77	OPERATING POWER (W) AC	DC
4	13	CPU DATA REDUCT. AND PRINTER	75-3	1																	X						X			150	-
		(GAS BOTTLE ASSY)-BEHIND RACK	58-6																		X						X			-	-
		CPU POWER SUPPLY	75-4	1																	X						X			30	20
		FLOW-VOLUME ELECTRONICS	58-3																		X						X			220	-
		SPIROMETER	75-5	1																	X						X			-	-
		BLOOD PRESS. MEAS. SYS. (BPMS)	49-7	1															X											150	-
		RADIO ISOT. SURV. MET. LIQ. SCI.	68-4		X																				X					150	-
		FLOW CONTROL UNIT	75-1	R																	X						X			800	14
		MIXING CHAMBER	75-2																		X						X			14	-
	14	RADIO ISOTOPE AIR MONITOR	76-28		X	X						X													X			X		-	50
		INTERFACE PANEL	58-4	1																	X						X			-	20
		(SPACELAB ICRS)	-																											-	-
		MASS SPECTROMETER	58-1																		X									-	100
		PNEUMOTACHOMETER	58-2																		X									-	50
		STRIP CHART RECORDER	58-5																X		X									220	-
		URINE ELECTROLYTE ANALYZER	77-1																										X	-	50
		(SPACELAB EPSP AND RAU)	-																											-	29
6	15	RODENT WATER SUPPLY	3-5			X		X		X	X			X	X															50	-
		RODENT HP CONT./DISPLAY	3-7			X		X		X	X			X	X															50	-
		RODENT HOLDING FACILITY	3-6			6		20		6	20			25	24															-	-
8	16	INSTRUMENTS/SUPPLIES	3-3			X																								-	-
		STOWAGE BLOOD ACQ. KITS	8-1					X	X																X	X				-	-
		RADIO ISOTOPE SAMPLES	68-1																						X			X		-	-
	16/17	SURGICAL WORKBENCH	68-3			X			X	X	X	X		X	X	X	X	X							X	X				300	-
	17	STOWAGE AUDIO. & BALANCE PIN	23-1												X	X														-	-
		STOWAGE - RADIOACTIVE WASTE	3-2			X						X																		-	-
		STOWAGE - WASTE	59-13																			X	X							-	-
		(SPACELAB - EPSP)	-																											-	-
10	18	METABOLIC CAGE AIR FILTERS	59-11																			X								100	-
		METABOLIC RCVR/PYR. TUNING	59-4																			X	X							150	-
		OSCILLOSCOPE SELECTOR	59-10																			X	X							-	-
		DATA LOGGER	59-1																			X	X							350	-
		TAPE RECORDER - ANALOG	59-2										X						X			X	X	X				X		200	-
		TORSION BALANCE (SLIDE)	23-2												X															-	-
		METABOLISM FLOW METERS	59-3												X							X	X							50	-
		CAGE AIR FLOW CONTROL	59-6												X							X	X							50	-
		POWER SUPPLY	59-8																			X	X							200	-
	19	RAT WATER SUPPLY/ACCESS	59-9																			X								50	-
		OSCILLOSCOPE	59-14																			X						X		200	-
		AIR (GAS) ANALYZER/M.S. SEQ.	59-5																			X								100	-
		(SPACELAB - EPSP)	-																											-	-
		METABOLIC CAGES	59-7			X				X					X							X								-	-
		DRIERITE COLUMNS & CAGE CTRL.	59-12																			X								50	
		(SPACELAB - EPSP)	-																											-	
12	20	CTRL CALIBR. GASES	76-25																									X		-	-
		M.S. CALIBRATION CONTROL	76-18		-																							X		-	25
		SIGNAL CONDITIONER	76-2																									X		50	-
		BUFFER AMPLIFIER	76-8																									X		25	-
		BUFFER AMPLIFIER	76-19																									X		-	50
		HEART RATE/DIFFER. PRESSURE	76-9																									X		50	-
		MASS SPECTROM. & SAMPLE VALVES	76-20																			X						X		-	25
		MASS SPECTROMETER CONTROLS	76-21																			X						X		-	50
		LOOP CONTROLS	76-10																									X		-	-
		BARATRON-AMP. PRESSURE	76-23																									X		25	-
		PART. PRESS. RATIO COMPUTER	76-24																									X		25	-
		(SPACELAB - EPSP)	-																											-	-

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TABLE 6. MATRIX, LIFE SCIENCES EQUIPMENT-NON RACK-INSTALLED

LOCATION	NAME	END ITEM	OTR	CORE	EXPERIMENT NO.																								OPERATING POWER (W)	
					3	5	8	10	11	12	13	15	21	23	27	39	42	49	51	58	59	60	66	68	74	75	76	77	AC	DC
END	FROG GIMBAL PLATFORM (STOW)	66-8																					X						-	-
AISLE	MONKEY PODS(A&B)	76-1/22																									X		-	-
"	X-15 FLOOR MOUNT	15-9										X																	-	-
"	ROTATING BASE ASSEMBLY	49-4																X	X				X						-	300
OMD	RODENT TRANSPORTERS	3-1	18		X			X	X	X	X		X	X	X						X	X							-	-
"	PRIMATE TRANSPORTERS	15-10	18									X				X											X		-	-
OVHD	HEMATOCRIT CENTRIFUGE (STOW)	8-2					X																	X	X				20	-
REFRIG.	FROG-HOLDING FACILITY	66-7																					X						100	-
AISLE	MICROSCOPE-ARM MOUNT (STOWED)	68-9																					X						25	-
"	MONKEY OSC. PLAT. & ACCEL. (STOW)	15-1										X																	-	-
OAFD	RESPIRATION RATE MODULE	5-1				X																							7	-
"	GALVANIC SKIN RESPONSE MOD.	5-2				X																							7	-
"	ELECTROMYOGRAPH MODULE	5-3				X																							7	-
"	BLOOD VOLUME PULSE ELEX	5-4				X																							5	-
"	HEART RATE MODULE	5-5				X																							7	-
"	STOWAGE DRAWER	5-6				X																							-	-
ORB. MID-DK	ULTRASONIC (DOPPLER) FLOW METER	49-6																X											420	-
STOW	MICROSCOPE	68-2																						X					2	-
"	MATING CAGE	68-5																						X					-	-
POD ASSY	TEMPERATURE MULTIPLEXER	76-13																									X		25	-
"	BASE, POD A	76-15																									X		-	-
"	BASE, POD B	76-12																									X		6	-
"	PODS INTERFACE PANEL	76-3																									X		2	-
"	MONKEY POD FOOD DRAWER	76-27																									X		-	-
"	H_2O COLLECTION/FILTER ASSY	76-29																									X		25	-
"	FEEDER/WATER SUPL. SIGN. CONDIT.	76-31																									X		-	50
"	CAMERA DRAWER, MONKEY POD	76-32																									X		-	-
"	WATER STORAGE DRAWER	76-14																									X		-	-
STOW	HAND HELD VOICE RECORDER	51-1																	X										-	-
STOW	ELECTRODES & AMPLIFIER-STOWED	66-6																X					X						-	10
STOW	TILT TABLE/LITTER CHAIR	51-2																X	X										-	120
STOW	TILT ANGLE TRANSDUCER	49-9																X											-	-
BELOW FLOOR	PUMP ASSY	76-33																									X		125	-

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Requirements (GPR) Experiment Definition Package prepared by Rockwell International Space Division under contract to NASA, dated July 1977 (Reference 70).

2.1.4.2 Summary of Dedicated Life Sciences Anomalies

The extraordinary requirements of this mission mainly involve the handling of the specimens. Considerable space and resources will be required in a KSC laboratory to maintain the many specimens in a flight worthy condition prior to launch. Periodic testing, injections, and surgery are carried out prior to launch and after landing. The KSC Handbook does not clearly define capabilities of this type off-line laboratory. This problem was coordinated with KSC.

The live specimens used must be put on as late as possible prior to launch and removed as soon as possible after landing. This indicates that they must be carried on and off by the crew. The KSC Handbook does not treat the cases in which items are carried on and stored in the Orbiter for launch and reentry. This is also a problem in quick removal of live or frozen specimens after landing. This type of problem requires coordination with Orbiter flow such that the specimen holding facility can be "bolted in" without affecting the Orbiter scheduled flow. The specimen transporters are then carried on and installed into the specimen holding facility at the launch pad.

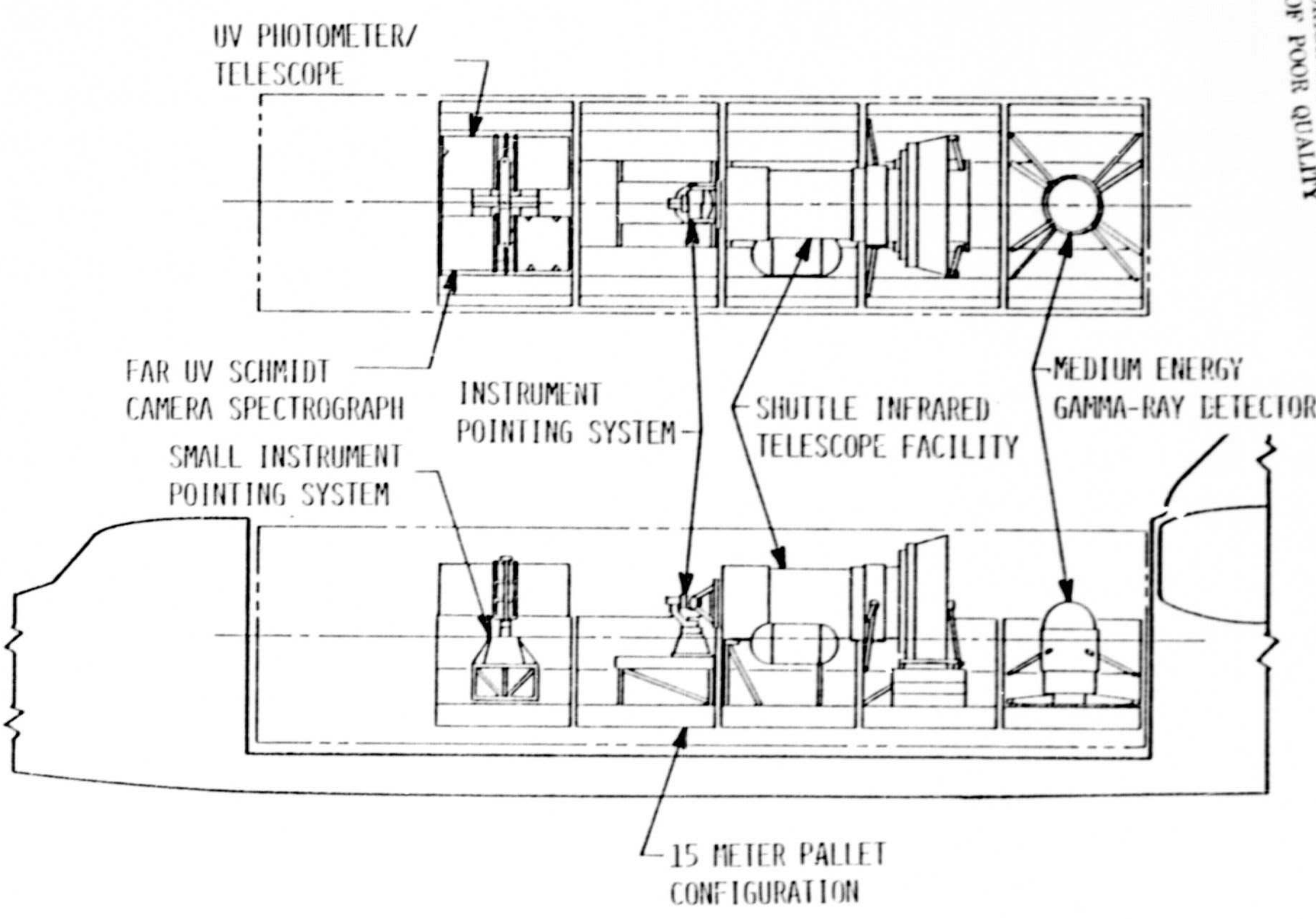
An LN_2 flask of the LN_2 unit/freezer requires precooling, then emptying of the LN_2 just prior to installation in the Spacelab module. This must be completed prior to Spacelab closeout for access. Upon being contacted, the data source stated that it is acceptable to perform this task at the latest module interior access time in the OPF.

2.1.5 Combined Astronomy

2.1.5.1 Mission Definition

The Combined Astronomy mission consists of five standard 3-m pallets as shown in Figure 7. The instruments mounted on the pallets are listed in Table 7. There is no Spacelab module involved in this payload and no planned EVA's. The Medium Energy Gamma-Ray Detector utilized a single pallet. The Shuttle Infrared Telescope Facility uses a two pallet train. The Instrument Pointing System utilizes a single pallet. The Far UV

FIGURE 7. COMBINED ASTRONOMY PAYLOAD CONFIGURATION



Schmidt Camera/Spectrograph and UV Photometer/Telescope are contained in separate Small Instrument Pointing System (SIPS) canisters. These canisters are mounted on the SIPS pedestal which in turn is mounted on a single pallet.

TABLE 7. COMBINED ASTRONOMY INSTRUMENTS

- SHUTTLE INFRARED TELESCOPE FACILITY (SIRTF), AS-01-S
- UV PHOTOMETER/TELESCOPE, UV-2
- MEDIUM ENERGY GAMMA RAY TELESCOPE, GR-1
- FAR UV SCHMIDT CAMERA/SPECTROGRAPH, AS-05-S

2.1.5.2 Summary of Combined Astronomy Anomalies

The following anomalies were solved by coordination with the experimenter:

- Cryogenic servicing with LN_2 and LHe required at O&C for LIMS, CIMATS and SIRTF instruments
- Class 100 class area required for offline service of Medium Energy Gamma Ray Telescope
- Continuous power required by payload during ground operations by LFC, SIRTF and UV Photometer/Telescope
- Ne replenishment required at landing site by Medium Energy Gamma Ray Telescope
- Continuous dry N_2 purge required by SIRTF and UV Schmidt Camera

Timelines for cryogenic chilldown and subsequent fill and topoff for SIRTF are not yet defined. Current thinking at the time was that chilldown with LN_2 will be initiated approximately T-70 to 80 hours and will continue until approximately T-24 hours at which time supercritical helium chilldown and loading starts. Topoff will require access to the LHe tank, thus the payload bay doors will have to be opened at the pad. Use of an umbilical from the Orbiter midbody panel for topoff is not feasible due to the inherent instability of supercritical helium and its handling problems. Cryogenic boiloff from the tank may require that the payload bay vents be opened on the pad to prevent overpressure. Amount of boiloff is not known but the tank is being considered for redesign (triple wall) which should alleviate this problem. This includes instrument integration and testing with the Spacelab in the O&C Building.

No payload operations are planned during vehicle assembly building operations which include rotating the Orbiter from horizontal to vertical and subsequent mating to other Shuttle elements and the mobile launch platform.

2.1.6 LAUNCH SITE ACCOMMODATIONS HANDBOOK ASSESSMENT

The accommodations handbook should provide the payload owner/ instrument developer with a clear picture of the functional flow and resource available for the ground operations. The normal or routine processing capability for payload ground operations should be baselined. Variations from this baseline which are allowable (usually at the expense of the payload owner) must be identified. Areas in the normal routine where variations are not allowed under any circumstances must also be described.

TBE suggested a revision which puts more emphasis on the payload processing while maintaining adequate treatment of the Shuttle turnaround process. It was recommended that some information be eliminated from the current issue of the handbook in favor of including information of more concern to the payload user. This change would help shorten the handbook and make it easier to read. The manual referred to all non-KSC organizations as the payload owner. The responsibilities of the experiment developer and integrated payload owner/operator are distinctly different. It was assumed that the integrated payload owner/operator meant the payload mission manager/ sponsor or his delegated representative. The definition of experiment developer is the principal investigator or other person responsible for the design and use of a single instrument and its associated support equipment.

Where specific information could not be given in the handbook, using the host concept, the experiment developer is directed to coordinate with the Launch Site Support Manager (LSSM). Because in the early planning stages there is no LSSM, the handbook should show with clarity the launch site capability for non baselined accommodations.

To assess the handbook, a set of review criteria was developed. Using these as a basis for handbook review, specific suggestions for revising the handbook were generated. These suggestions, which included organization, content, and level of detail, were transmitted to KSC as they were generated. The key recommendations for handbook revision were to:

- Reorganize to present material from user viewpoint.
- Simplify to include only material pertinent to payload.
- Clearly define payload flow and flow operations.
- Be consistent and thorough in describing and noting availability of resources at each facility.

Specific suggestions were given to reorganize Section 3, Payload Ground Operations at KSC of the handbook. These were to define two payload functional flow paths, one for horizontally integrated payloads and another for vertically integrated payloads. It was recommended that definite criteria for selection of the path taken by particular payloads be defined. The flow paths should start at the payload arrival at KSC, continuing through integration, launch, landing and ending with the return of the payload to the owner or storage. Using the flow as an outline, the accommodations available and operations performed at each of the process functions should be given.

Suggestions for revision of Section 4, Facilities and Launch Site GSE of the handbook were given. These included simplification of the figures showing facilities locations, combining payload, facility and function information in a single matrix; and standardizing the facility accommodation descriptions.

The KSC accommodation handbook defines a set of resources for each of the facilities which contribute to the processing of a Spacelab payload. The resources were compared with the review criteria to assess their adequacy. The results of the assessment for the O&C Building, Orbiter Processing Facility, Vehicle Assembly Building, and Launch Pad were presented in Reference 2.

2.2 GROUND PROCESSING REQUIREMENTS FOR GENERIC PAYLOADS

2.2.1 Purpose

The purpose of this subtask was to:

- Develop a set of launch site payload processing steps which are generally required to check out a minimum risk Spacelab payload. These processes should provide technically adequate verification of the payload for assurance of mission success. This may require more stringent processing criteria than payloads in the "acceptable risk" category. The intent in either

category was to minimize launch site processing and to state each requirement in well defined terms with enough detail to support the definition of implementing procedures and constraints.

- Define the conditions under which requirements should be satisfied, modified or deleted in terms of different assigned risk categories.
- Define the special support necessary to implement the processing requirements.

2.2.2 Scope

The resulting document defined the launch site processing requirements to:

- Verify payload functional interfaces, both software and hardware.
- Verify payload to Space Transportation System (STS) compatibility.
- Verify flight readiness of instruments which are sensitive to transportation or time/cycle limited.
- Verify Payload-to-Payload Operations Control Center (POCC) compatibility.
- Verify functional integrity of payload data flow through both software and hardware.

This document was intended to be a standard which defines the requirements for processing a Spacelab payload through Level III, II and I integration at KSC. These requirements were defined in sufficient detail to allow for the implementation of equipment and procedures.

2.2.3 Guidelines and Assumptions

The following guidelines and assumptions were used in formulating and establishing the launch site processing requirements.

- The normal status of a payload as it is received at the launch site is based on the MSFC Level IV concept. This concept is to ship an integrated and verified payload to the launch site.
- All Spacelab equipment and interfaces will have been checked out and verified prior to the start of Level III/II payload integration. All Spacelab equipment and interfaces will have been verified to meet or operate at or within their published specifications.

- All individual experiment equipment will be performance tested prior to Level IV. Exceptions will be handled as they arise on a case by case basis.
- All test requirements will be satisfied at the earliest possible point in the processing sequence.
- Interfaces previously tested that were demated for shipment, will be remated and subsequently reverified at the launch site. Those not demated will not require interface verification; however, they will be verified during system functional testing.
- Experiment software packages, including DEP software, will have been validated at Level IV, using a non-flight computer and a Command and Data Management System (CDMS) simulator.

2.2.4 Payload Integration and Operations Concept

The payload integration concept was presented in terms of mission manager assigned risk criteria, with maximum integration and checkout occurring as far upstream of the launch time as is permitted by available equipment and payload development status. The Level IV integration concept involving the integration of experiments into Spacelab racks and pallets was presented to provide an adequate description of the state of Spacelab/payloads upon arrival at the launch site. The launch site processing (Levels III/II and I) concept was described in more detail considering interface verification, instrument performance verification, software functional acceptance testing. experiment calibration and alignment, servicing, compatibility, payload to POCC validation and end-to-end testing.

2.2.5 Test Requirements

The test requirements were defined for all electrical, data, communications, mechanical and thermal interfaces. The specific point in the process flow where a requirement is satisfied was not designated. A breakdown of each required test and an indication of where it should be performed are tabulated in our report. Interface tests will be performed each time the interface is connected, or whenever it is disconnected and then reconnected during the ground processing flow. Interfaces will be inspected for proper mating of connectors and then functionally checked to verify operation of all affected circuits.

Detailed electrical interfaces were identified in terms of functions to be verified at the Experiment Power Distribution Boxes (EPDB) (Module Mounted), Aft Flight Deck Power Distribution Box (AFDPDB), Experiment Essential Power/Experiment Emergency Power, and Ground and Isolation.

Data interfaces to be checked out include the Experiment Checkout Equipment (ECE) and payload CDMS interfaces. Caution and Warning interfaces to be checked were defined in detail for module and pallet configurations. Specific utility wiring checkout requirements were defined. Required mechanical interface verifications were specified.

2.2.6 Software Validation and Functional Acceptance Testing

A three part process was defined to certify that software was ready for use. These are verification, validation and functional acceptance testing.

Verification and validation normally occur prior to receipt of the software at the launch site. The functional acceptance testing of software is performed at the launch site on the flight hardware to verify interfaces with the MMU, DDU/keyboard, MDM, PCMMU, HRM, ECAS and mission peculiar ECOS (CDT & GML lists). Launch site processing requirements for calibration, alignment, servicing and maintenance were generally defined subject to particular payload requirements.

2.2.7 Special Support Requirements

Special processing requirements for data processing and display, recording, playback and dubbing, facilities, Ground Support Equipment (GSE) and data distribution system were defined.

2.3 OSTA PAYLOAD INTEGRATION COST STUDY (References 28, 31 & 32)

The purpose of this study was to supplement information available from Task I and provide information on OSTA payloads necessary to perform ground operations cost estimates and ground operations analyses.

TBE reviewed other available integration study material for OA Payload 82-1A comprising a short module and 3 pallets with AMPA on one pallet, a consolidated experiment pallet with ATMOS on the pallet, and a pallet dedicated to SIR-B. Experiment support electronics were located in the short module. Certain required information was directly available from Task I experiment information sheets. Other parameters were derivable from available integration studies and some information was synthesized.

Experiment requirements from Task I data sheets provided information on experiment, component, location, extent of preintegration, data rate, TV utilization, cooling, storage, caution & warning and pyrotechnics. Available integration studies provided information on experiment, mounting/installation, purge, vent/vacuum, cooling duct, umbilical, post integration service/monitor and Level I access. Particular questions regarding the individual tape recorder, experiment descriptions, detailed experiment cooling, data rate, caution and warning provisions, power, payload peculiar mounting platforms, launch lock and deployment, late access, cleanliness, instrument alignment and special tests were answered for this specific payload. TBE also provided data on special Level IV test requirements and Level IV interfaces for branching units, electrical power distribution boxes, battery requirements, number of software modules, experiment switching panel power and experiment disconnect panel (module aft bulkhead).

3.0 EXPERIMENT COMPUTER ACCOMMODATION

3.1 ECOS REQUIREMENT DOCUMENT REVIEW

In October 1977, TBE was requested to participate in a Team 1 review of the September 1977 Experiment Computer Operating System (ECOS) Requirements Document. After review of the document, 19 Review Item Discrepancies (RID's) were submitted for consideration of the Review Team. After these and other RID's from the review were considered, TBE participated in the follow-up action on four RID's.

3.1.1 Review Item Discrepancies

A brief description of the Review Item Discrepancies submitted by TBE and their disposition follows:

Hazardous Command- It was recommended that provision be made for checking commands for hazardous conditions which may be caused by their execution. The recommendation was disapproved because:

- No rigid definition of hazardous conditions is available and it is not clear what causes a hazardous condition.
- Any capability of general nature would tax the ECOS memory which is already at premium.
- The capability can be provided by application software if required.

Audible Alarm- It was recommended that audible annunciations be used to indicate hazardous error conditions and ECOS provide the software necessary to enable such an audible alarm. The recommendation involves a hardware change which is beyond the scope of ECOS. No change is required in the ECOS Requirements Definition Document. The recommendation was transmitted to the proper authority.

Dual "+"/"-" Keys- Suppression of redundant "+" and "-" keys appearing on alphanumeric keyboard and among the function keys was recommended. The recommendation was accepted. Another RID on the same subject was received. The redundant "+" and "-" function keys were to be removed.

Display Formats- It was recommended that Section 3.6 read "As stated generally in the preceding paragraph, a display page will be divided into four areas (1) system (2) data (3) fault message area and (4) keyboard input." The recommendation was accepted. The ECOS Requirements Definition Document was modified accordingly.

Lower Case Alphabet - The elimination of 26 lower case alphabetical characters was recommended to possibly reduce the EC memory overhead. At present, the existence of lower case alphabetical characters is doubtful. Further, the elimination of lower case alphabetical characters would increase the EC memory burden. No change was recommended in response to this RID.

Sampling and Limit Checking of Serial Digital Data- It was recommended that ECOS include the option of sampling and/or limit checking experiment/DEP serial digital data inputs. The recommendation was initially disapproved but was later incorporated in the ECOS requirements.

Prevention of MMU Overwrites- It was recommended that ECOS provide a capability to track MMU locations so that MMU overwrites do not occur. The recommendation was accepted. ECOS capability to prevent MMU overwrite will be made compatible with that of SCOS and any clarification will be added in Section 8.4.1 of the ECOS Requirements Definition Document.

DDU/Keyboard Interchange- It was recommended that provision be made for interchange of DDU/Keyboard assignments through ECOS software. A capability will be provided so that upon keyboard failure, data can be displayed on its DDU by command through another Data Display System (DDS). Clarification was made in Sections 3.1.1 and 3.1.2.

Tutorial Display -It was recommended that the PS Command and Control Page be eliminated if it is purely tutorial. The recommendation was accepted. The PS Command and Control page will be eliminated.

Application Tracking- It was recommended that a key be included among the special function keys which will flip through all pages currently in the memory on a 1 to 2 second stay time basis. The recommendation was disapproved because a capability exists to call any page by only three keystrokes. It is anticipated that providing an application tracking key would only complicate the ECOS.

Timeline Inhibit - It was recommended that messages be sent to the ground when the timeline is inhibited or enabled. In response to this RID no change was recommended because timeline inhibit/enabled is transmitted to the ground as a part of transmission of keyboard entries to the ground.

Simultaneous Independent Operation of Payload Specialist Stations- Clarification of the fact that ECOS permits simultaneous independent operation of data display systems was recommended. It was accepted and the necessary changes were made.

Functional Designator Use- Clarification was sought if a command may be given via the keyboard through a function designator for an application which is not currently being displayed on the DDU. It was clarified that it is not possible to transmit a command to an application whose page is not being displayed. A clarification to this effect was added in the document. A command function key was considered which would provide this capability.

HRM Capacity Indicator- It was recommended that ECOS provide a self test and fault indicator to indicate HRM overload. It is doubtful that there would ever be a problem of overloading the HRM. No action was taken on this RID.

Operator Advisory on Applications Requiring Attention - Clarification was sought on the function of the Hidden Page Advisory (HPA) and the use of FAULT SUMMARY in blanking the HPA was questioned. It was agreed to add another paragraph to clarify HPA function. A discrepancy in FAULT SUMMARY command has been identified and correction will be made as necessary.

DDU Page Availability in EC Memory- Clarification was sought as to the maximum number of DDU pages to be supported by ECOS. The maximum number of DDU pages to be supported by ECOS is nine and was clarified in Section 3.5.

PCMMU Bit Rate- Clarification of PCMMU access bit rate in Section 11.2.1 was sought. Clarification was made in Section 11.2.1.

PCMMU Buffer Size- It was recommended that PCMMU buffer be kept minimal and be limited to accommodate the specific payload data to be transferred. There is no specific answer as to what should be the size of the PCMMU buffer. Disposition was postponed pending definition.

PCMMU Buffer Designators- Clarification as to what payload data are to be sent via PCMMU was sought. This is related to the above RID. The subject was to remain an open action item.

3.1.2 Action Items

Time Accuracy/Resolution (Reference 14) - TBE conducted a study to determine the time accuracy and resolution. The GMT of an event can be determined to an absolute accuracy of ±10 ms. The relative time between two events (resolution) can be determined to 10 microseconds by the experimenter if he provides a counter which is clocked by the 1024 KHz clock. The counter information can be utilized to accurately time tag the data within the Experiment Computer (EC) after GMT-UTC correlation.

Tutorial Display (Reference 35) - TBE participated in the evaluation of tutorial display options proposed and performed analyses of impacts on EC memory. TBE participated in the MSFC tests to evalute the utility of tutorial display options which were designed to determine total time to perform an experiment/task, segment time to perform each command, total number of keystrokes per task, keystroke errors, time consumed in consulting supporting documentation, quantity of supporting documentation, and error in interpreting input/output data.

TBE provided support to the development of the malfunction model. The malfunction model consists of failures which occur as a function of time and send messages to the PS station simulator. TBE reviewed a number of Experiment Requirement Documents (ERD's) to identify probable failure modes.

Keyboard Language (Reference 23) - TBE performed an evaluation on alternate keyboard language including payload control language proposed by Goddard Space Flight Center. Analyses indicated the advantages and disadvantages as compared to the proposed ECOS keyboard language. The ECOS language was recommended since it maximizes similarity with subsystem operating system (SCOS) keyboard functions and will be easier for the payload specialist to use.

Serial Digital Channel Utilization - Follow up action on this item was performed to justify the provision for exception monitoring of serial digital channel through the RAU's on to the experiment data bus. Clarification of nomenclature and use with DEP's was provided. Data and commands to and from the Experiment Computer are transferred by Spacelab Payload Standard Modular Electronics (SPSME) via the serial input and PCM command channels of the RAU.

3.1.3 ECOS Requirements Document Review

The January 1978 issue of ECOS Requirements Document was reviewed by TBE and comments were furnished by Reference 33. This revision of the ECOS Requirements Document was reviewed for compliance with the recommendations of particular concern to the users. The document was found to be responsive to the user requirements.

3.2 Computer Interconnect Study

TBE performed a qualitative analysis of possible ways to augment experiment computer (EC) memory available for experiment applications programs by using existing software and hardware augmented interconnections with the other two Spacelab computers. This involved the determination of capacities of various interconnect options, their uitlity for EC memory augmentation, and possible interference with existing design functions.

A comparison of data rates, capacities and access times of the various alternatives considered indicated that any alternative other than the utilization of additional core memory cannot be recommended. Core memory access time of the order of less than 0.5 μs is over 2,000 times as fast as a bubble or disc Mass Memory Unit (MMU) could provide. A faster MMU is required quite apart from EC memory augmentation. There is no clear advantage to the attempt to augment EC capability by use of existing or modified links between computers. Disadvantages in terms of interference with the operation of other equipment involved indicate caution in further consideration of computer interconnection. The addition of 64 K-words of core memory to the EC may be the most efficient and cost effective solution.

4.0 STS ACCOMMODATIONS AND APPLICATIONS REFERENCE FILE

The purpose was to compile, in reference form, information which is readily usable by Spacelab Payload Project Office management personnel in communicating and understanding STS flight systems and ground operations accommodations and potential STS uses (applications).

The compiled information was directed at three levels of communications and understanding: NASA management, engineering (non-aerospace) personnel and the general public. The reference file is quickly and easily accessible. Special attention was given to making it simple. Information developed under Task I and Tasks 2.1 and 2.2 of this contract, together with other existing NASA documentation such as the various payload accommodations handbooks, user guides and handbooks, was used as source documents for this task. Descriptive information of certain flight experiment facilities necessary to impart an understanding of the capabilities and procedures for using these facilities to potential experimenters was developed. Topics included in this reference file are listed in Table 8.

TABLE 8. STS ACCOMMODATION REFERENCE FILE TOPICS

- Space Shuttle
  - Missions
  - Costs
  - Mission Sequences
  - Orbiter and its accommodations
  - Solid Rocket Booster
  - External Tank
- Spacelab
  - Accommodations
  - Typical Applications
  - Mission 1
  - Mission 2
  - Mission 3

TBE proceeded by inventorying available information as supplied by the COR. This information was reviewed for its compliance with the approved outline, reviewed for current technical accuracy and then filed in its appropriate place. A cursory assessment was made of the material requiring technical or philosophical update. An assessment was made of material needed to fulfill the outline. These assessments were used in the assignment of priorities for completion of the file.

Technical problems needing clarification or resolution were handled by direct interface with the pertinent organization at MSFC or communication with other centers as necessary. TBE also attended reviews/meetings where the subject matter was highly pertinent to the preparation of particular material. All material generated was initially prepared as a preliminary draft subject to review by the COR. Final copies were furnished to the COR as required.

The STS Accommodations and Applications Reference File consists mainly of graphics, drawings, and other illustrations with appropriate descriptive test pertaining to the Shuttle Transportation System. Many of these elements are derived from materials already in existence which were provided by TBE. Each was reviewed for technical accuracy and for its applicability to the referenced file requirements. Those elements requiring change were changed accordingly and subsequently filed. Other elements are original material generated to fill gaps where no reference material was available. Inputs to these elements came from the various accommodations handbooks, user guides, TBE accommodation task outputs, and current NASA documentation on STS applications. The material generated and accompanying text are included in the STS Accommodations and Applications Reference File maintained at TBE. All material is filed in the same order as the approved outline of subject headings. Each element of the file is given a unique index number for ready reference and identification. As each element was filed, an entry was made in a master index.

5.0 SPACELAB ACCOMMODATIONS FOR PAYLOADS

5.1 ACCOMMODATION DEFINITION

The current status of payload accommodations by the STS/Spacelab has been summarized (Reference 5). The summary report contains information prepared by TBE for presentation to the NASA Joint User's Requirement Group (JURG) on May 3, 1978 by Mr. J. W. Thomas of MSFC. The information presented there is supplemented by backup data and explanatory notes to make it more usable to the Spacelab payload planner.

This summary provides a base for engineering assessment of these accommodations against projected payload requirements. The accommodations descriptions are organized and of sufficient detail to evaluate the accommodation of payload requirements. The accommodations are described as they affect the integrated payload. STS accommodations are included when they constrain payload operations.

The primary source of data was the Spacelab Payload Accommodations Handbook (SPAH) (Reference 52). Information on the software came mainly from the ECOS REquirements Definition Document (Reference 56) and the Software User's Guide (Reference 71). These data sources were supplemented by personal contact with MSFC personnel in Science and Engineering.

The report is subdivided into sections dealing with mission capability, Structural and Mechanical accommodations, Environmental Control, Electrical Power Distribution, Command and Data Managment, Software, Pointing and Stabilization, Ground Operations, General Systems Concerns, and a Summary Assessment. Each subsystem area deals with the resources available, equipment furnished and principal constraints which impact payload accommodation. The configurations of Spacelab available and definitions of Spacelab furnished equipment, mission dependent equipment that must fly with each configuration, and optional MDE is given in the structural and mechanical accommodations section. Each of the subsystem sections describes the accommodations constraints, and resources available to the payload for that discipline.

Once the accommodations were summarized, they were compared with the Spacelab System Requirements (SRD) (Reference 72). Areas where the accommodations do not meet the SRD requirements are listed as discrepancies. These discrepancies are shown at the end of each section. In some areas (e.g. Structural/ Mechanical) the SRD requirements were so general, that discrepancies could not be identified.

Each section contains a list of concerns which have a potential impact on the accommodation of Payload requirements. Many of these items were brought out during the recent Spacelab Critical Design Review (CDR) and are therefore called CDR concerns. These concerns, while not necessarily discrepancies in accommodation vs specified requirement, may limit or restrict the payloads. Some of these concerns are already being worked towards a solution, and where possible the status is shown.

At the end of each section there is a list of areas of potential improvement. This list contains near term and long term improvements which could make the Spacelab more flexible and better able to accommodate payload requirements. These lists were generated after comparing known payload requirements with the defined Spacelab accommodations.

The accommodations and resources described are those available for payload discretionary use. They do not include items such as MDE which must fly (and over which the payload has no control), but are payload chargeable. The rack volume and panel space reported, for example, are available to the payload to be used at the discretion of the payload planner. The required volume and panel space for subsystem air ducts, fire suppressant equipment, Remote Acquisition Unit (RAU), electrical power switching and access has been subtracted from the total rack volume and panel space to arrive at the values for payload use.

The significance of this report becomes evident when considering the SPAH stated 8.85kW of heat rejection to the Spacelab and payload. Only 3.2 kW is available for payload discretionary use in the long module plus pallet configuration. Similarly, of the SPAH stated 7 kW electrical power to the Spacelab and payload as little as 1.3 kW is available for payload discretionary use in the module configurations.

There are significant constraints for data handling. The analog inputs through the RAU have a response from dc to only 20 Hz. The serial data rate throughout the RAU is limited to a maximum of 13.6 Kbps. The High Data Rate Recorder and payload recorders are used to store downlink data during TDRS obscuration and are not available for use by the payload. If the payload digital data being downlinked has a rate greater than 2 Mbps, no wideband analog data can be simultaneously downlinked.

5.2 ACCOMMODATION ASSESSMENT FOR PAYLOADS

Reference 30 reported on a quick look (2 weeks study) at five defined missions. They were the Office of Applications Mission 83-2, Spacelab III (Strawman), Office of Applications Mission 82-1A, Combined Astronomy and Dedicated Life Sciences Missions. The flight accommodation of these missions in the areas of structures and mechanical, electrical power, environmental control, software and data management was considered. Because of the short turnaround time, the study was based on payload descriptions already in our possession. (These descriptions have since been updated for use in a later asseesment.)

In spite of the quick look approach, this study showed electrical power to be a problem for Spacelab III, OA 82-1A and Dedicated Life Sciences. The requirement for a small instrument pointing system was identified for the OA 83-2, OA 82-1A and Combined Astronomy missions. Other problems identified were heat rejection on Spacelab III, cryogenic servicing for Combined Astronomy and specimen loading/unloading for Dedicated Life Sciences.

A second and more thorough study, Reference 6, provided an assessment of 3 generic missions. The emphasis of this study was on flight accommodations with principal problems in ground accommodations noted.

This description of Spacelab accommodations discussed in Section 5.1 was the basis for assessment against payload requirements. Available data from 3 selected missions: Earth Observations, Combined Astronomy and Dedicated Life Sciences (described in Section 2) were analyzed and the payload accommodations requirements of each mission determined. This required the consideration of experiment requirements and mission definitions along with the synthesis of integrated payload requirements.

The payload reqirements were formulated from experiment and mission descriptions already available. A minimum attempt was made to check instrument/experiment compatability or to adjust the integrated payload definition. The Spacelab Payload accommodations assessment was the prime concern. The data source for Earth Observations Mission was based on the most recent Office of Space and Terrestrial Applications (OSTA) Planning Data resulting from direct contact with the Principal Investigators (PI)/ Project Sponsors and a payload layouts produced by MSFC inhouse studies. The Combined Astronomy and Dedicated Life Sciences mission requirements were based on the instrument/experiment and payload descriptions contained in the North American Rockwell Ground Processing Requirements (GPR) Experiment Definition Packages received in November 1977.

The significant problems and Spacelab improvements supported by these missions are shown in Table 9.

5.3 SPACELAB PAYLOAD ACCOMMODATIONS IMPROVEMENTS

One of the purposes of the definition of Spacelab Payload Accommodations and the assessment of these accommodations against various generic payload requirements was to determine what Spacelab payload accommodations improvements are needed. TBE participated in the determination and documentation of these improvements based on our own and MSFC's extensive experience in analyzing payload and integrated mission requirements. The culmination of this effort was the preparation of Narrative Justifications for the Spacelab Payload Accommodations Improvements which we prepared using our own and MSFC inputs.

TABLE 9. ACCOMMODATIONS ASSESSMENT SUMMARY

DISCIPLINE	PRINCIPLE PROBLEMS	SPACELAB IMPROVEMENTS SUPPORTED
MISSION OPERATIONS	• EXPERIMENT TO EXPERIMENT INTERFACE/ CONNECTIONS OF DEDICATED LIFE SCIENCES	NONE
STRUCTURAL/MECHANICAL	• RECORDER FOR SIR-B TOO LARGE FOR AFD (EARTH OBSERVATIONS)	• SPACELAB PROVIDED PALLET MOUNTING PLATFORMS (EARTH OBSERVATIONS) • RELAXED RACK C.G. CONSTRAINTS (DEDICATED LIFE SCIENCES) • SPACELAB PROVIDED RACK CLOSEOUT PANELS (DEDICATED LIFE SCIENCES)
ENVIRONMENTAL CONTROL	• AVIONICS AIR AND CABIN AIR LOOP CAPABILITY INSUFFICIENT FOR DEDICATED LIFE SCIENCES • 12 EXPERIMENT COLD PLATES REQUIRED BY EARTH OBSERVATIONS • ACOUSTIC LEVELS EXCEED DEDICATED LIFE SCIENCES EXPERIMENT LIMITS	• ADDITIONAL AVIONICS AIR LOOP AND CABIN AIR HEAT REJECTION (DEDICATED LIFE SCIENCES) • ADDITIONAL COLD PLATE AND HEAT EXCHANGER IN MODULE (DEDICATED LIFE SCIENCES) • VARIOUS SIZED COLD PLATES (EARTH OBSERVATIONS) • STANDARD PROVISION FOR HEAT EXCHANGER AND VENT ON EITHER SIDE OF MODULES (DEDICATED LIFE SCIENCES, H/X ONLY)
ELECTRICAL POWER DISTRIBUTION	• INSUFFICIENT POWER FOR DEDICATED LIFE SCIENCES	• 2 kW ADDITIONAL POWER
COMMAND AND DATA MANAGEMENT	• WIDEBAND ANALOG AND DIGITAL DATA MUST BE TIMELINED ON EARTH OBSERVATIONS	• INCREASE HRM BUFFER SIZE (EARTH OBSERVATIONS)
SOFTWARE	NONE	NONE
POINTING AND STABILIZATION	• POINTING ACCURACY CANNOT BE MET FOR EARTH OBSERVATIONS (TBE ESTIMATES EXPERIMENT REQUIREMENTS CAN BE RELAXED • POINTING STABILITY CANNOT BE MET FOR EARTH OBSERVATIONS	NONE
GROUND OPERATIONS	• CRYOGEN SERVICING AND VENTING FOR EARTH OBSERVATIONS AND DEDICATED LIFE SCIENCES • BIOLOGICAL SPECIMEN INSTALLATION AND REMOVAL FOR DEDICATED LIFE SCIENCES • EXPERIMENT TO EXPERIMENT INTERFACE/ CONNECTIONS OF DEDICATED LIFE SCIENCES	

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